PRINCETON
Mechanical & Aerospace Engineering

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3:30 PM

Flame Synthesis of Oxide and Carbon-Based Nanomaterials and Study of Their Growth Mechanisms using In-Situ Laser -Based Diagnostics

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Flame synthesis of materials has demonstrated a history of scalability and offers the potential for high-volume commercial production, at reduced costs. Flame synthesis of ceramic oxide nanoparticles, semiconducting metal-oxide nanostructures, carbon nanotubes, and graphene will be discussed. TiO_2 nanoparticles are produced from corresponding organometallic vapor precursors using an axisymmetric stagnation-point premixed flat flame impinging on a cooled substrate under uniform electric field application. Using counterflow flames, other nanostructures, such as $WO_{2.9}$ nanowires, ZnO nanoribbons, and MoO_2 nanoplates are synthesized, whereby growth occurs by the vapor-solid mechanism, with local gas-phase temperature and chemical species strategically specified at the substrate for self-synthesis. Carbon nanotubes and graphene are grown on metal substrates at high rates using a novel multiple inverse-diffusion flames synthesis method in open-atmosphere environments. Finally, flame synthesis combined with solution synthesis to produce novel nanostructures will also be discussed, along with laser ablation in liquids. Laser-based diagnostics enable non-intrusive in situ characterization of the gas-phase synthesis flow field (e.g. temperature, species concentrations), as well as the as-formed nanomaterials themselves during flame synthesis, permitting fundamental understanding of the physical processes and growth mechanisms involved. Well-known techniques, such as laser-induced fluorescence (LIF) and Raman spectroscopy, can be utilized to characterize the gas-phase flow field (e.g. temperature, species concentrations). Moreover, novel developments of existing techniques have been recently used for in situ nanomaterials characterization during synthesis. Specifically, low-intensity phase-selective laser induced breakdown spectroscopy (PS-LIBS), for detection of the formation of nanoparticle phase, and in-situ Raman, for identification of nanoparticle crystallinity, are discussed. These techniques allow us to characterize particle composition and crystallinity and to delineate the phase conversion of nanoparticles, allowing for better understanding of the governing growth and kinetic mechanisms.

Prof. Tse received his B.S.E. in Engineering Physics from Princeton University in 1991, and his M.S. and Ph.D. in Mechanical Engineering from the University of California at Berkeley in 1994 and 1996, respectively. He was a Post-doctoral Researcher and Research Staff Member at Princeton University from 1997 to 2000. In 2001, he joined Rutgers University as an Assistant Professor, receiving his tenure in 2006. He is presently Professor, Outreach Director, and Mary W. Raisler Distinguished Teaching Chair in the Department of Mechanical and Aerospace Engineering. Prof. Tse's research focus is in the thermal sciences, involving applications in nanomaterials synthesis, microgravity processes, combustion and propulsion, and advanced laser-based diagnostics. His research methodologies encompass experimentation; computational simulation of complex flows, chemistry, and molecular dynamics; and mathematical analysis. He has designed experiments and diagnostics that have flown on the Space Shuttle or are being planned for the International Space Station. He was Chair of the AIAA Microgravity and Space Processes Technical Committee, and was Chair of the Public Policy Committee on the ASME Board of Government Relations. At Rutgers, he is Co-Director of the Center for Nanomaterials Research, and executive member of the Institute for Advanced Materials, Devices, and Nanotechnology. He is currently the Technical Chair of the 2017 ASME International Mechanical Engineering Congress & Exposition.

Social Period outside of Maeder Hall, following the seminar

ALL VISITORS ARE WELCOME